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HEAD AIMING/TRACKING ACCURACY IN A HELICOPTER ENVIRONMENT.(U)

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(6) HEAD AIMING/TRACKING ACCURACY IN A HELICOPTER ENVIRONMENT

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This experiment was conducted to measure man's head aiming/tracking capability using a helmet mounted sighting device . The influences of target speed, helmet suspension types and helmet weighting parameters on head aiming/tracking were investigated. If the aiming/tracking accuracy was sensitive to manipulation of these man-machine interface parameters, then it would seem to indicate that improved aiming/tracking accuracy could be obtained by improving the interface.

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The subject sat in a modeled AH-1 (Cobra) copilot's crewstation which was attached to the Multi-axis Helicopter Vibration Simulator (MAHVS). The MAHVS vibration was programmed using an analog FM recording from x,y, z coaxial accelerometers mounted to the floor in the copilot's crewstation of an AH-1G. The Cobra flew the same mission profile the MAHVS was to simulate. A light in the center of a photocell array was used as a target for the subject to track. The 32x32 photocell array and target light moved in a quasi-random spherical path with constant velocity and a constant distance of 80 inches from the subject's eye position. The target traversed an area of 110° in azimuth and 45° in elevation. A beam of infrared light was projected from a small telescope mounted on the subject's helmet. This light beam was boresighted with the subject's reticle projector. As the subject tracked the target by superimposing his reticle on it, the coincident beam of infrared light would energize the appropriate photocell(s).

The data were analyzed as though two independent factoral experiments had been conducted. The factors analyzed in case I were: eye dominance, helmet weighting, target speed and subjects. The factors analyzed in case II were: helmet suspension, helmet weighting, target speed and subjects. This paper presents the major finding of the experiment and discusses the conclusion and recommendations as presented to the hardware development agencies.

HEAD AIMING/TRACKING ACCURACY IN A HELICOPTER ENVIRONMENT

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INTRODUCTION

Much interest has been generated in the aerospace community during recent years concerning visually coupled systems (VCS). A VCS can be defined as a closed-loop technique utilizing the natural visual and motor skills of the operator to control a system function. The development of methods to accurately and remotely measure head position has enabled design engineers to use the head as a control device. When the head tracker is used to orient an electro-optical (E-O) sensor whose video information is being viewed on a display also mounted on the head, a VCS is achieved.

In airborne applications of VCS, some of the head-tracker and display hardware must be mounted on the crewmember's helmet; thus, the terms helmet mounted display (HMD) and helmet mounted sight (HMS) are used to identify the display and tracker respectively. Since the helmet alone introduces considerable weight to the operator's head, the additional weight contributed by the VCS hardware must be kept to an absolute minimum. This restriction is not only necessary so the aviator's safety is not compromised, but also so his performance is not encumbered.

PURPOSE

This experiment was conducted to measure man's head aiming/tracking capabilities using a helmet mounted sighting device. The influences of target speeds, helmet suspension types, sighting eye dominance, and helmet weighting parameters were investigated. If accuracy was sensitive to the manipulation of these man-machine interface parameters, then it would seem to indicate that improved aiming/tracking accuracy could be obtained by improving the interface.

METHODOLOGY

A thorough analysis of the empirical data obtained from flight tests and static bench tests of HMS devices indicates head aiming/tracking accuracies with a mean radial error of 13.5 milliradians (mr) have been obtained. In order to measure the man's capability alone, a device was designed which would measure static aiming accuracies to within 1.6 mr using a cooperative target. This device consists of a 32 X 32 photocell array.

The activating source was a quartz iodized lamp with an IR 740 nm high pass filter. The energy from the lamp passed through a light

weight non-coherent fiber-optic lightguide to a light weight telescope mounted on the subject's helmet. The emerging beam of IR light was boresighted with the subject's reticle. The beam of light was 5/8 ± 1/8 inch in diameter as it impinged on the photocell array. The IR beam was not visible to the subject. Also mounted on the subject's helmet was a sight reticle generator that provided an illuminated reticle of adjustable intensity. The collimated reticle could be viewed by either eye.

A diffused miniature lamp installed in the center of the photocell array was the target. A computer turned on the lamp to indicate the initiation of a tracking/aiming trial and turned off the lamp at its conclusion. The photocell board with the lamp/target was moved in a quasi-random direction at predetermined constant velocities. The speeds of the target were 0°/sec, 4°/sec, and 8°/sec. The target moved at a constant velocity throughout each 30 second tracking trial, but the direction and magnitude of the acceleration vectors were constantly changing. The targets traversed a spherical path ± 50° in azimuth and + 30° to -15° elevation with a radius of 60" from the crewmembers design eye. The target servos followed commands generated by a hybrid computer. The same quasi-random path was used for each subject.

A 45-minute tactical scenario was flown in an attack helicopter (AH-1G) with three orthoganal accelometers secured to the copilot/gunner floor panel. The acceleration measured there was recorded as X, Y and Z vibration components. This tape was recorded twice on a 90-minute tape to be used throughout the test sequence. A time code was added to the tape so that the hybrid computer could synchronize the aiming/tracking tasks with a vibration pattern according to a predetermined schedule.

The six aviator subjects were fitted with form-fit helmets using wax molds of the aviators' heads from which plastic head forms were made. The foam liners for each SPH-4 helmet were then fitted to each individual's head form. The hard foam liners were covered with soft foam and leather. Absorbent cotton skull caps were worn by the subjects to reduce heat discomfort.

The weight and center of gravity of the test helmet were adjusted to conform to the weight and center of gravity of the standard issue SPH-4 during the symmetrically weighted condition and the projected integrated helmet display/sight (IHADSS) weight and center of gravity with the display during the asymmetrically weighted condition.

RESULTS

The independent variables in this study were eye dominance, helmet suspension, target speed, and helmet weighting. The dependent variable was aiming/tracking accuracy expressed in milliradians (mr) root mean

square (RMS) error. There were two levels of eye dominance, dominant and non-dominant eye used for aiming/ tracking; two levels of helmet suspension, form-fit and sling; and two levels of helmet weighting, symmetrical and asymmetrical. There were four levels of target speed: high (target moving 8°/second; subject vibrating), low (target moving 4°/second; subject vibrating), static (target static in one of the locations; subject static), and test (target moving 4°/second, subject static).

Six combinations of eye dominance, helmet weighting, and helmet suspension variables were administered to the six subjects. Each combination was considered a separate treatment. The six treatments were:

A. Dominant eye, symmetrical weighting and form-fit helmet suspension.

B. Dominant eye, asymmetrical weighting and sling helmet suspension.

C. Non-dominant eye, symmetrical weighting and form-fit helmet suspension.

D. Non-dominant eye, asymmetrical weighting and form-fit helmet suspension.

E. Dominant eye, symmetrical weighting and sling helmet suspension.

F. Dominant eye, asymmetrical weighting and form-fit helmet suspension.

A six by six Latin square order of presentation was used to minimize the learning effects.

The aiming/tracking data collected during this study are analyzed as though two separate experiments had been conducted. In Case I, eye dominance data are analyzed in addition to helmet weighting and target speed. The form fit suspension is a constant factor for the Case I analysis. The data for the Case I analysis are obtained from treatments A, C, D, and F.

In Case II, helmet suspension data are analyzed in addition to helmet weighting and target speed. The dominant eye is a constant factor for the Case II analysis. The data for Case II analysis are obtained from treatments A, B, E, and F.

In Case I and Case II, the factors were completely crossed and the treatments were counterbalanced. The p values less than 0.1 are considered statistically significant. For Case I, the eye dominance factor is statistically significant ($p<0.009$), but the helmet weighting factor is not statistically significant. The target speed factor has overwhelming statistically significance ($p<0.001$). None of the interactions are statistically significant.

For Case II, the helmet suspension factor is not statistically significant ($p<0.32$), and neither is the helmet weighting factor ($p<0.224$). Again, the target speed factor is statistically significant ($p<0.001$). None of the interactions are statistically significant.

DISCUSSION

The experimental data were obtained to allow hardware decisions to be made based on objective data rather than speculation. With this thought in mind, the discussion will emphasize the practical significance of the experimental results.

The aiming/tracking performance of the subjects, although statistically better with the dominant eye, is improved on the average 6.1% when the dominant eye rather than the non-dominant eye was used.

The mean performance using the symmetrically and asymmetrically weighted helmets was essentially the same; no statistically significant difference was observed. The subjects did complain the asymmetrically weighted helmet caused "hot spots" and headaches. There were usually red marks on the forehead and around the left ear (weight was over the right ear) at the end of a day's testing when the subjects wore the asymmetric helmet. However, this discomfort did not degrade aiming/tracking performance.

When the target was static and the subject was static, the average RMS error was 3.5 mr. With target movement 4°/second, the error increased to 11 mr. When the subject experienced vibration too, the error increased to 13.3 mr. An increase of target speed to 8°/second caused the accuracy to further decline to 16.5 mr. The changes were 2.2, 2.8, and 3.7 fold, respectively, from the static condition.

The aiming/tracking performance was statistically different for the four levels of the target speed factor ($p<0.001$) for the Case II analysis also. The changes for Case II were 2.6, 3.4, and 4.3 fold, respectively, from the static condition. In both cases, the target speed factor accounted for an overwhelming proportion of the data variability.

The aiming/tracking performance was not statistically different for the sling and form-fit helmet suspensions ($p<0.32$). The subjects seemed to think they were performing better with the sling fit but the novelty of the form-fit may have influenced their comments.

CONCLUSIONS

The only factor showing practical significance was target speed although eye dominance also was statistically significant. The accuracy

difference in the eye dominance factor was 6.1% while the difference in the target speed factor was in the 200 to 400% range. The data obtained at each of the four levels of the target speed factor are considered of practical significance. Quantification of the basic head aiming error of about 3 to 3.5 milliradians (pooling over all other factors) is a relatively important human performance capability to have determined. This aiming error increases drastically as the subject is required to track a moving target; the tracking error increases more than 2.5 times. Data were not collected with the target static and the subject vibrating. The increased error contributed by the subject vibrating in addition to the target moving at 4°/second amounts to only 20% . The psychomotor demands of tracking a target with overt head motion is much more demanding than simply aiming at a fixed target as one would expect a priori. The increased error caused by moving the target twice the rate (from 4°/second to 8°/ second) is about 26%.

The results of this study indicate that improving the man-machine interface with more comfortable and better fitting helmets and selectable sighting eye will not enable man to significantly improve his head aiming/tracking capability.